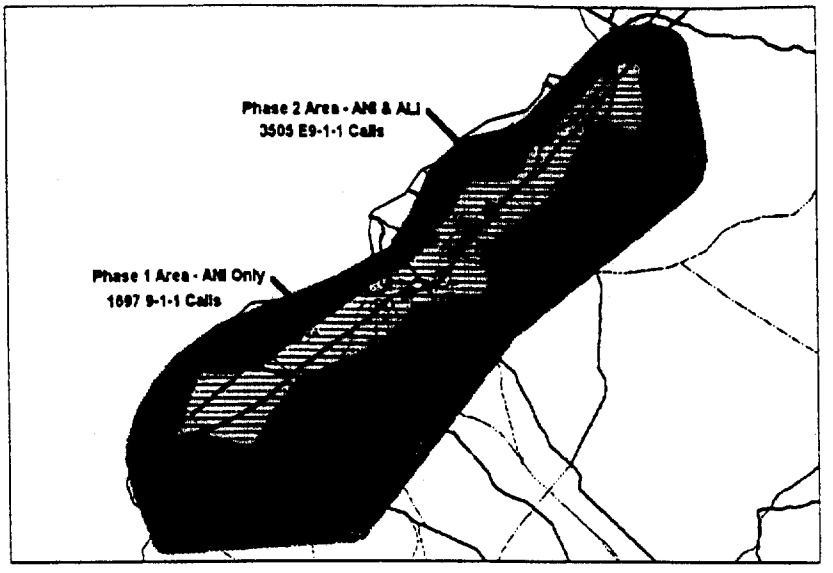


Figure 10 - Phase I/Phase II Area

The trial system was configured so that wireless E9-1-1 callers that were located in the Phase II coverage area of the system were routed to the appropriate PSAP based upon the 9-1-1 caller's calculated location. In all 3,505 cases, the call was routed to the correct PSAP. In contrast, wireless E9-1-1 callers served by the Phase I portion of the trial system were routed to the PSAP closest to the cell site at which the 9-1-1 call originated. These callers were routed to an inappropriate PSAP approximately 30% of the time. This occurred because cell site radio coverage frequently overlaps the geographic boundaries of multiple PSAPs. Additionally, wireless calls do not always connect to the closest cell site, especially if the closest cell site is busy handling other calls. Thus, the PSAP closest to the cell site may not be the cell site closest to the caller.

B. Operational Impact on PSAPs

PSAPs today face many challenges in processing wireless E9-1-1 calls. Most wireless users do not realize that emergency personnel have very little, if any, information about their location. The dispatcher on the other end needs to obtain information and communicate calmly to the caller that their call is being processed as quickly and efficiently as possible. One PSAP administrator in the trial area summarized this best by saying: "When you dial 9-1-1 you expect the other person on the phone to know where you are. We have to have the ability to quickly locate the caller and route them to the appropriate PSAP."

Over the course of the trial, OETS met regularly with PSAPs and interviewed E9-1-1 directors and public safety telecommunicators about the wireless location system and its impact on their ability to respond to calls. County 9-1-1 directors reported frequently to OETS about specific situations where the use of the technology further facilitated their operations. The reaction was extremely positive, with the consensus from the PSAPs that the wireless location system greatly improved their ability to respond to emergencies in a timely, efficient manner. As one dispatcher said: "This system takes the *search* out of search and rescue." There were several areas in which the trial demonstrated the positive effects of using the technology:

1. Location Accuracy

Public safety telecommunicators reported that the location technology accurately reported locations of wireless callers during the full period of the trial. In no case did a response unit report being dispatched to an incorrect location.

2. Routine Nature of Location System

In interviews with PSAP directors and public safety telecommunicators, it was evident that this technology became a routine part of handling 9-1-1 calls. Rather than an occasional high-profile event, life-saving assists occurred every day. Harrowing, drawn out searches like the famous South Dakota example were avoided because locations were immediately provided, and response times were reduced.

For example, in one incident, a 69 year old woman from out-of-state was visiting relatives late one night. She lost complete power in her car because of a broken alternator. Unable to get out of the car because of recessed power locks, she dialed 9-1-1 to summon help. Because it was late at night and she was stuck in a rural area, she was unable to identify any landmarks and she misidentified her exact location. The dispatcher was able to determine an accurate location because of the TruePosition location system, and a State Trooper was dispatched to the scene and relatives were called to help. The situation was fully resolved in less than 15 minutes.

In another incident during the test period, a wireless E9-1-1 call was received reporting a motor vehicle accident on "Jacksonville Road". The caller could not tell the dispatcher which of four possible Jacksonville Roads in the general area was the right one. The dispatcher was able to see the exact location on the PSAP terminal and send an emergency unit to the scene.

Stories like these became routine occurrences during the system trial. PSAP directors also explained that while adjacent areas were forced to deal with threatening phone calls and bomb threats, no such incidents were reported in the trial area during the test from wireless calls.

3. Efficiency of PSAPs

The public safety telecommunicators reported that the time of response to a wireless calls was significantly reduced. Previously, public safety telecommunicators responding to a wireless caller would need to spend several minutes asking questions about the area in order to determine where the call was coming from and attempt to narrow down the location before sending units to respond. During the trial, public safety telecommunicators were able to access the mapping section and find the caller within seconds. For example, the Camden County Coordinator stated: "It is quite evident that because of the triangulation of this cellular 9-1-1 call, the investigation time was greatly reduced. Without it, who knows how long it would have taken to find this MVA [motor vehicle accident]." PSAPs estimate that using the technology, they were typically able to respond and process the average wireless E9-1-1 call under a minute.

Public safety telecommunicators reported that the system helped them manage incoming calls to the PSAPs and coordinate better with informed outgoing requests for assistance to emergency response units. Throughout the State, administrators and public safety telecommunicators often report being overwhelmed with wireless calls, but impeded in their ability to dispatch help properly. The opposite reaction was had by users of this new wireless location system. A participant said: "The new system has not been a problem for the dispatcher. What it has done is raise the comfort level of everyone." Another stated: "The trial made our 9-1-1 center much more efficient, increased the individual capacity of each telecommunicator, and allowed us to serve greater numbers of callers with the same resources."

Public safety telecommunicators also reported that the system assisted them in weeding out duplicative calls from the same location to report traffic accidents, disabled vehicles, etc. Prior to the trial, public safety telecommunicators were often frustrated because they would receive multiple calls with various location descriptions from the wireless callers. Because they did not have the location of the call, they needed to answer

and process each one of them. Because they could not be sure where the emergency was located, they often dispatched multiple units to respond to multiple locations. However, a PSAP official who participated in the trial said: "This technology is helping the well being of every dispatcher. With it they know where the call is coming from so that multiple calls can be removed from the system quickly and appropriate help can be directed to the emergency. Without the technology, we have to figure out if callers are referring to the same accident. People will call with, 'I just passed an accident on Route 55, but don't have any exact location'."

Although the increase in usage of wireless telephones means an increase of E9-1-1 calls for PSAPs, the ability to determine caller's locations in very short periods of time saves PSAPs time and allocates the use of public safety telecommunicators and emergency resources in a more efficient manner. Without wireless location technology, the burden on PSAPs will continue to increase with no means of effectively managing and handling it. One County Coordinator stated: "The percentage of calls from wireless users is now approaching 50%, and has increased steadily even over the last year. With our resources, if we don't implement a system like this, I don't see how we'll be able to respond quickly enough to the calls."

The trial also highlighted the challenges and impact of E9-1-1 in a non-urban setting. A dispatcher said: "In rural areas there are not a lot of road signs and in some areas the nearest intersection may be 2-3 miles away. You can walk blocks and still have no idea where you are." The incident where the woman was stuck in her car at night on a country road is a perfect example. Wireless E9-1-1 may have its greatest impact for PSAPs to locate callers not helped by the seeing the nearest exit sign on an interstate or closest mile marker on a highway. Trial participants also report additional uses for a wireless location system. "When this technology is fully operational it will also have a big impact on boaters on the Delaware River and the Delaware Bay. When a boater breaks down, they have a great deal of difficulty figuring out where they are. When you have a mix between commercial vessels and recreational boaters on the water, it's important to find distressed boaters."

4. Integrating Location Technology System

The PSAPs involved in the trial reported no difficulties in using the new system and indicated that there was little or no transition time once the trial commenced in January. The new system was easy to use and user friendly. The same PSAP terminals and mapping computers for wireline E9-1-1 calls were used for wireless E9-1-1 calls. One dispatcher said, "Everything I needed to know was right there on the screen in front of me within seconds - the caller's number and a map showing the caller's location. Instead of spending time asking a lot of questions, I was able to assure the caller I knew where he was and that a unit was on its way to help him."

During the trial, system integration posed little problems for operators and far outweighed the resources needed to use the system. Some of this success is due to the fact that New Jersey has a coordinated statewide 9-1-1 network, which many states do not. However, the overall success of the trial was only made possible with the total dedication of all of the participants.

C. Operational Impact on New Jersey's Existing Wireline 9-1-1 Network

Aside from the usual short term errors encountered in any first time trial, the other components of the trial functioned very well. For example, when OETS first approached Bell Atlantic-New Jersey about participating in the project, the idea was greeted with mixed reactions: "Being out front is both challenging and rewarding, as long as you are successful. We were, after all, talking about running an experimental process through a wireline network that was handling over thirteen thousand live 9-1-1 calls every day." As the scope of the trial became apparent, questions were raised - most of which showed concern:

- What effect would this trial have on the rest of the network?

- Would the new software changes inhibit call processing in the 9-1-1 tandems?

- Could signals received over the new location/selective router system interface corrupt the 9-1-1 tandem's database, or bring the tandem down completely?

- What if the location system was hopelessly inaccurate, and if so, who would be held responsible and have to perform damage control?

- What if the location system was a lemon and what would it cost to dedicate the resources to keep it afloat for the trial period?

During the initial round of planning meetings, it became obvious to all of the participants that this would be a well planned and organized venture, run by people who knew their business and were dedicated to the success of the team. Bell Atlantic-New Jersey and Comcast Cellular installed Feature Group D signaling between the Comcast's Mobile Switching Center (MSC) and Rockwell's SCX 9-1-1 Tandem Switch. This required new interface software in the Rockwell switch and programming in the MSC.

Second, a new data link interface was created to accept routing and location information for delivery to the PSAP. These were new untried interfaces on a live 9-1-1 tandem. If the location system, selective router system or PSAP terminals had to be taken off line because new features were not working properly, these changes could be done without affecting 9-1-1 service. This could not be said for the 9-1-1 switch. It had to continue functioning no matter what else happened.

Perhaps what is most significant, is what did not happen. While the concerns stated above were appropriate, the wireless location system integration went extraordinarily well. The new software and interfaces functioned as expected, thanks to the technical support from Rockwell and Bell Atlantic, who loaded and constantly monitored the functioning of the software. Routing and location data were passed to and through the 9-1-1 tandem as designed. There were no "side effects" that inhibited normal 9-1-1 call processing in the tandem. There were no cases of errant transmissions corrupting the tandem's database. In fact, the system worked so well that the initial concerns eventually evaporated, and it became an accepted part of the overall network. As one of the participating entities said: "It can be said that it became routine, which is about as good as it gets."

All of the participants were proud to participate in the New Jersey wireless project and would like to see the system expanded and made permanent. They continue to remain dedicated to improving the quality of life through enhanced 9-1-1 and the intelligent use of technology. Accordingly, the trial is continuing with several changes being made to the system to improve its location ability.

V. Location System Testing and Accuracy

A. Testing Procedures

1. Testing Methodology

The accuracy of the wireless location system was measured through extensive testing. Before the initiation of the trial, OETS had planned to measure the accuracy of the system by requesting PSAP operators and public safety telecommunicators to use an electronic map terminal to compare a caller's TruePosition-calculated location with the caller's "actual" location as reported verbally during the call. However, two problems were encountered with this planned testing methodology. During emergencies, public safety telecommunicators are heavily engaged in responding to the emergency (i.e. gathering critical details, dispatching and routing ambulances, coordinating resources) and frequently do not have the time to record trial information before the next emergency call arrives. Second, people involved in an emergency have difficulty explaining their exact location in sufficient detail to make a meaningful estimate, which is, after all, the reason we need the new technology in the first place. A typical verbal estimate might be "a quarter mile past the Route 30 overpass," which is not sufficient to verify a 410-foot accuracy requirement.

Therefore, all participants in the trial adopted a testing approach that involved organized drive testing of the system. The location system was configured such that it would locate both wireless E9-1-1 callers and phones identified as test phones. Various test points along the New Jersey Turnpike, I-295, as well as off-highway test points were accurately surveyed using Differential Global Positioning System (D-GPS) receivers. In excess of 100 separate test points were surveyed in this manner. The drive testing was accomplished by sending drive test volunteers in vehicles to the test points, where the volunteers would place test calls. Between 1 and 100 test calls might be placed at various test points during each day of drive testing, depending on the test objective for the day. The system recorded the calculated locations of the test calls into a database for analysis. In addition to the test calls placed during drive testing, the TruePosition development team placed test phones at fixed sites throughout the trial area. These phones were automatically located approximately every 10 to 15 minutes as a continuous measure of the performance of the location system.

Additional testing was conducted by other parties including Comcast, OETS staff, the E9-1-1 Public Safety Agencies of Salem, Gloucester, and Camden counties, and a large, independent telecommunications company, all of which reported similar results.

OETS believes that the drive testing described above is representative of the performance of a location system during actual emergency calls. The participants monitored the profile of actual emergency calls, and concentrated testing in those areas where the most number of E9-1-1 calls were received.

2. Numbers of Test Calls

The following number of test calls were placed during the trial period:

65, 445 test calls were placed by TruePosition from test phones at a number of fixed places throughout the trial area.

11,064 test calls were placed by the TruePosition development team during drive tests of various portions of the coverage area.

5,247 test calls were placed by the other parties, such as Comcast, personnel from Salem, Gloucester, and Camden counties, and a major independent telecommunications company.

Over 81,700 test calls were placed, of which over 16,300 were from drive testing. This represents extensive dedicated testing when compared to the 3,505 actual E9-1-1 calls received during the trial period in the coverage area. Examples of test calls are shown below:

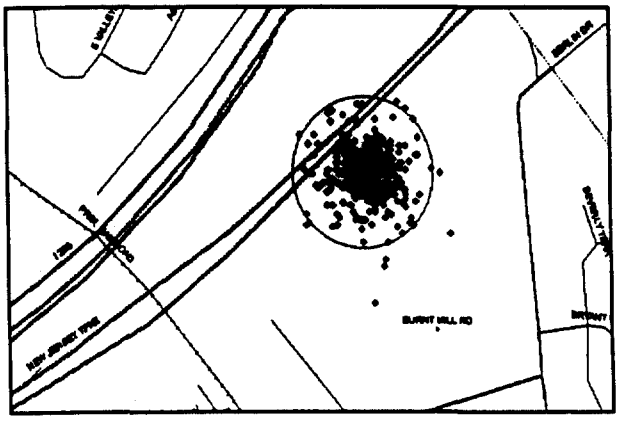


Figure 11 – Example of Multiple Calls From Test Phone At Fixed Place

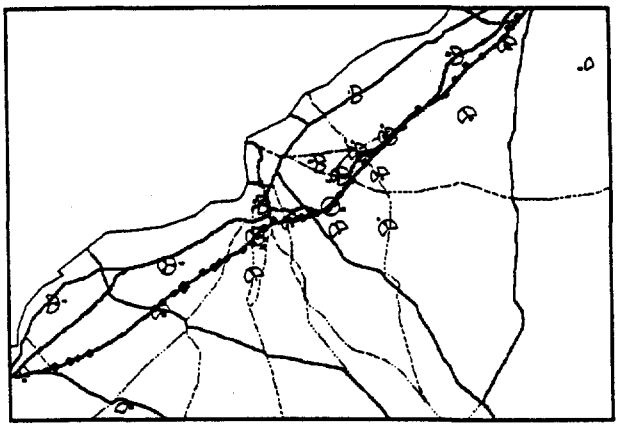


Figure 12 – Example of Drive Test by 9-1-1 Personnel

In each of the two examples above, each test call is represented on the plot by a single diamond, or point. Multiple diamonds clustered tightly together means that multiple test calls were made, and similar location estimates were made by the location system. In Figure 11, the circle drawn in the plot has a radius of 125 meters (410 feet) around the actual location of the fixed phone. In figure 12, personnel from Salem, Gloucester, and Camden County PSAPs drove the entire 50 mile section of the New Jersey Turnpike, placing test calls at various points on the route. On this particular drive test, the location errors ranged from 50 to 700 feet. The aggregate data presented later is a composite of many tests such as the ones shown in the above examples.

B. Accuracy of Location Measurement

1. Summary

OETS concludes from this test experience that the TDOA location system tested is capable of meeting the FCC Report and Order Phase II requirement of accuracy to at least 410 feet for 67% of wireless 9-1-1 calls. OETS also concludes that this technology was highly valuable to the PSAP public safety telecommunicators and to the calling public because of the reduction in response time when a wireless caller could not identify his/her own location.

OETS and the trial participants also learned about changes that would be required in moving from the current trial system design to a future fully operational location system. For example, the TDOA location technology tested exceeded the FCC location accuracy requirement of 410 feet, 67% at several test points, but did not meet the accuracy requirement at all test points. The reasons for the these differences in performance at different test points seems largely related to the manner in which the location system receivers were installed in the field, also known as the system design. The location system receivers were installed at 55% of the cell sites in the trial, with the distribution of the receivers varying widely over four separate coverage zones. Additionally, the receivers were deployed in a manner more conducive to achieving location performance parallel to the New Jersey Turnpike. By changing the system design for a fully operational system, including covering a greater percentage of cell sites and arranging the receivers in a more circular or square pattern over a wider area, OETS is highly confident that the FCC location accuracy requirements can be met at all test points in the future.

The accuracy results can be summarized as follows:

- The technology used in the trial solved the real world problems PSAP operators are having with the explosion of wireless E9-1-1 calls. In anecdotal feedback, the live wireless E`9-1-1 calls produced no complaints from public safety telecommunicators of incorrect locations.

- The results of the program testing, including the improvements made during the test period, give OETS a high degree of confidence that technology exists today to create operational wireless E9-1-1 location systems meeting or exceeding the FCC's Phase II accuracy requirement. In the better coverage areas (high enough ratio of location receivers to cell sites, high ratio of receivers per mile, and better receiver placement), the location system met or exceeded the FCC's Phase II accuracy requirements. Operational systems need to have higher overall coverage than was used in this test (only 55% of the cell sites had receivers).

- The overall test *average* error declined from 1,400 feet during the preliminary operations in early January to 635 feet at the end of April due to significant engineering changes made by the TruePosition development team based on lessons learned during the testing. The lessons learned could not have been known prior to testing of a location system on such a wide scale (350 square miles). Unfortunately, the commitment to daily operate a full time, live wireless E9-1-1 system prevented certain system changes that would allow further accuracy improvements. These changes could have only been made by essentially terminating the test.

- Due to the long, narrow system design of the coverage pattern, parallel results (error measurements that run parallel to the New Jersey Turnpike and I-295) were more accurate than transverse results (error measurements that run perpendicular to the New Jersey Turnpike). This was of great practical value when locating vehicles on highways.

- The technique used by TruePosition for synchronizing its receivers was not as stable as desired over many days, and over the length of the coverage area. The technique, known as external calibration, had been successfully used in smaller trial areas by TruePosition, but the technique did not scale as well as planned. TruePosition identified an improved synchronization technique during the initial trial period which will be intergrated into the system as the trial continues.

2. Operational Results

At the operational level, accuracy was reported to be excellent by the PSAPs. OETS received no reports or complaints of incorrect locations from public safety telecommunicators or their public safety clients. As discussed elsewhere in this report, PSAP operators were extremely pleased with the results.

3. Organized Testing Results

In organized testing, OETS observed that the performance of the location system both varied from test point to test point, and varied from day to day. The test point variability is generally related to the coverage of the location system relative to the coverage of the cellular system hosting the location system. That is, the cellular system covering the trial area currently uses 43 cell sites, while the trial location system used receivers at only 24 of those sites. This is a coverage ratio of only 55%. More importantly, the arrangement of the receivers in a long, narrow corridor distorted the accuracy performance, providing better performance parallel to the Turnpike and worse performance transverse to the Turnpike. Based on the lessons learned in this first-ever wide area location system trial, OETS and TruePosition now estimate that a normal deployment of receivers for a fully-operational system should be at 80% to 100% of cell sites.

The day to day variability was primarily related to the manner in which TruePosition synchronizes the receivers of a location system. The design goal of a TDOA location system is to maintain time synchronization between the receivers at all of the cell sites to within 30 nanoseconds (30 billionths of a second). TruePosition's confidence in its particular technique, known as external calibration, was based upon previous test results in several smaller location system technology trials. Unfortunately, the technique did not scale as well as hoped in moving from smaller trial areas, 20 square miles or less, to the larger New Jersey trial area of 350 square miles. On some days, and at some times, the synchronization error ranged as high as a few hundred nanoseconds. This directly contributed several hundred feet of error to the location estimates at some test points. Midway through the trial period, TruePosition identified an improved synchronization method as stated above and will be incorporated as the trial continues.

a. Operational Zones

One of the purposes of the test was to determine the optimum coverage pattern, or system design, required to achieve a high degree of accurate location readings. In other words, what number and placement of TruePosition receivers on a cellular system would deliver the best results at the most number of test points.

OETS and TruePosition share the opinion that a fully operational system would meet the FCC standard because it would correct for both the low (55%) use of location receivers, and the parallel placement bias (because operational systems would be designed for full area coverage, not focused on a narrow corridor of two parallel highways).

The New Jersey Turnpike / I-295 Corridor was divided into 4 separate zones as shown in the map which follows (Figure 13). These zones roughly correspond to the 4 counties involved in the trial, but also represent different coverage ratios of the location system relative to the host cellular system, different coverage ratios per

mile of highway, and different geometric placement patterns. The same type of analyses performed for individual test points was also performed for all test points that occurred within the zone. As demonstrated by the map, the coverage pattern overall was a long narrow strip, biased towards parallel coverage of the major highways, instead of being a complete grid matching the full cellular coverage of southern New Jersey. It turned out that this early system design decision was fundamental to a large percentage of the error margins observed. In reviewing the placement of the TruePosition location receivers, it is clear that the sources (angles) for transverse triangulation (at various angles to the two main highways) were far more limited than the sources of measurement parallel to the highways.

The TDOA system works most accurately when it can measure signals from a variety of location receivers surrounding a transmitting telephone: ideally like an eight-pointed star. In far too many instances, there were only two or three "points of a star" close enough to receive signals, and these were not evenly spaced around the telephone on the points of a compass.

The coverage zones are shown in the following diagram:

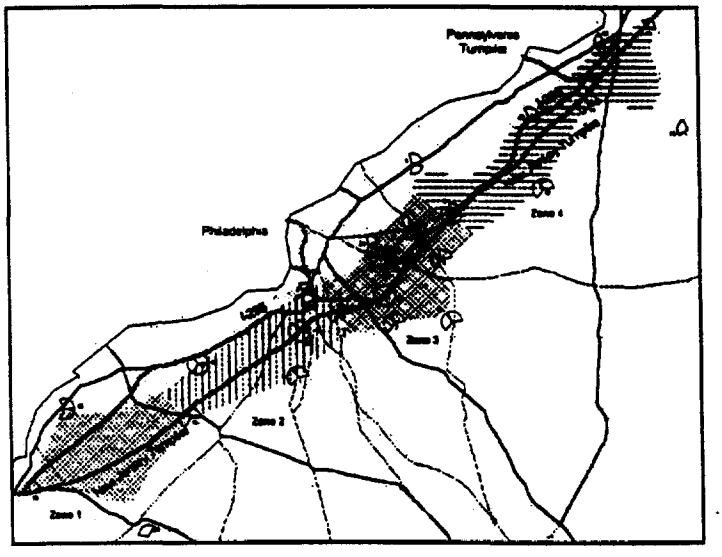


Figure 13 – Map of Four Test Zones

The first zone, at the southern end of the trial area (Salem County), is 10.8 miles long and is covered by location system receivers at four of the six cell sites. In this zone, location accuracy tended to be better in the center sections of the zone and test points closer to the corners of the zones performed less well. The first zone is rural in character.

The second zone, covering predominantly Gloucester County, is 8.1 miles long and has receivers on four of eight cell sites. Additionally, the configuration of receivers is more limited in the transverse direction (across the turnpike) than parallel to the turnpike. The second zone includes an area of reduced cellular coverage, and location performance of test points in that area was also reduced. This zone is suburban in character.

The third zone, corresponding to Camden County, is 10.6 miles long and has receivers on eight of eighteen cell sites. The relatively dense receiver configuration produced the most accurate results. This zone is also the most heavily populated, with a high number of multi-story apartment and office buildings. Besides turnpike and I-295 testing, many test points on residential streets were included in this area.

The fourth zone, covering Burlington County, is 16.2 miles long, with receivers on eight of eleven cell sites. This zone is also suburban in nature. Its length and placement of receivers negatively affected results.

b. Initial Results

OETS observed that the system performance underwent a significant improvement over time as the development team successfully identified and resolved various integration and scaling issues raised by this first large scale, wide area test of wireless location technology. This is a tribute to the Herculean effort and dedication of the TruePosition development team.

Organized testing began before the live trial was launched at the beginning of January, 1997. Initial results showed an average aggregate error of over 1,400 feet. A variety of software and hardware changes in the system during the live trial significantly improved the results as demonstrated in the following chart. The daily average error moved consistently downward until it was close to the FCC requirement a few days before the end of the first 100 days.

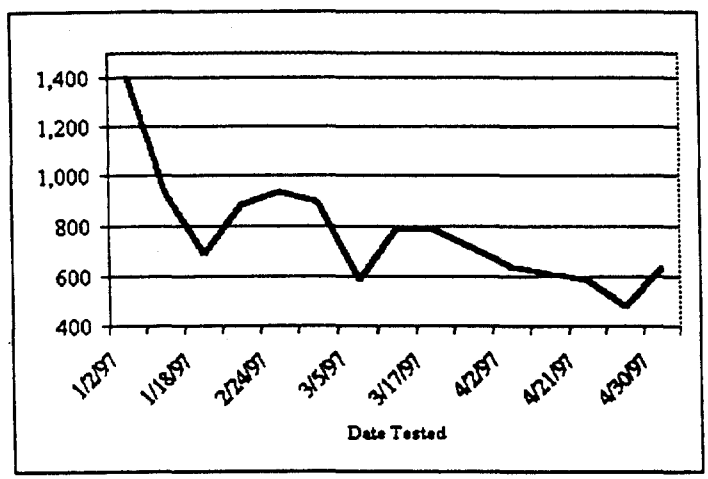


Figure 14 – Improvement of Location System Over Time (Error In Feet)

c. April Results

OETS has extensively analyzed the test data from the trial system, and concludes that technology exists to meet and exceed the 410 foot, 67% FCC Report and Order requirement. The analysis concludes that a permanently deployed, fully operational system should have a higher coverage ratio of location receivers to cell sites than the 55% used in the test.

Zone 3 had the best performance for all test points on all days in April, with 56% of all test calls within 410 feet. The overall system produced an average error of 635 feet.

OETS further analyzed the location system estimates to determine the portion of the error of the estimates that occurred parallel to the New Jersey Turnpike and the portion of the error that occurred transverse (or 90 degrees) to the Turnpike. This purpose of this analysis was to determine the effects that trial system coverage and the placement of receivers had on the results. The trial system was deployed as a long, narrow

system that was 50 miles long and only 7 miles wide. As discussed earlier, the overall coverage of the trial system was 55% (24 location sites / 43 cell sites), but when the coverage is examined in two dimensions (parallel to the highways and perpendicular to them, or roughly in the x- and y-dimensions), the coverage was better in the parallel dimension than in the transverse direction.

The overall performance (67% point) for all tests at all test points during April from all test participants was:

Zone	Aggregate Error	Parallel Error	Transverse Error
1	515	355	433
2	875	555	470
3	478	324	305
4	894	501	636

Note that zone 2 was heavily influenced by the results of a single test point in the data set. All data have been included for the sake of completeness. If the single test point from zone 2 (which occurred in a particularly poor coverage area of the both the cellular system and the location system) is removed and the remaining data is processed, the results would be:

Zone	Aggregate Error	Parallel Error	Transverse Error
1	515	355	433
2	695	409	486
3	478	324	305
4	894	501	636

As the above data show, results from measurements parallel to the two major highways were more accurate than transverse results for three zones, and approximately the same for zone 3 (which had the best system design), and in at least two zones exceeded the FCC Phase II requirement. This finding is of great practical value when locating vehicles on highways in rural areas is the most important need.

4. Problem Areas

The TruePosition system performance over the entire length of the New Jersey Turnpike test area was carefully monitored throughout the test. Early testing was mostly performed by the TruePosition development team to identify and isolate the performance of each element of the system. It became clear during the trial that further significant improvements in accuracy could only be made by "taking down" the system for a period of time to re-engineer and better implement certain aspects of the system. In other words, the live portion of the trial allowing real wireless emergency calls to be located would have been interrupted for a period of several days or longer. OETS made the decision to continue the live trial.

a. Coverage Factors Affecting Accuracy

By the end of the initial test period, it was clear that the system coverage as designed was too light. The TruePosition TDOA location technology rests on the complex application of simple geometrical principles. Its accuracy improves as the number of receivers with distinctly different perspectives to the wireless telephone increases, with best results achieved when the telephone is "surrounded" by at least four receivers relatively equally spaced around compass points.

If a telephone transmits on a direct line between two receivers, the system can relatively accurately position it on the straight-line dimension between those two, while producing much greater errors in transverse and therefore aggregate measurements. The relatively large number of receivers which were almost directly on the parallel of the New Jersey Turnpike and I-295 show why the parallel results noted above were far more accurate than the transverse or aggregate measurements.

From the drive testing data collected by PSAPs and various commercial trial participants for the month of April, it is clear that in certain locations accuracy was much better than in others. At specific points, latitude/longitude results were much better than the FCC's Phase II location requirements of 410 feet, 67%. In particular, several testing points in Zone 3 performed much better than the FCC Phase II requirements, and as a whole, Zone 3 produced the most accurate location results.

For the most part, the accuracy of the location technology throughout the trial depended on four interrelated factors. Taken alone, the data did not show an exact one-to-one correlation between each accuracy factor and each result. But taken as a whole, when these factors were satisfied by the system's engineering, the results were extremely accurate.

Of course, these factors were known before the test began, but the field test was critical because location technology had never before been tested on this scale. By actually testing these theories in the field, OETS and TruePosition partners believe that this trial provides extremely helpful data for performing future system designs to achieve optimal results.

(1) Density -- Build-out of wireless sites. The TDOA wireless location technology was not located on every Comcast Cellular Communications cell site (only 24 out of 43 total). Deploying at a larger number of cell sites would help to locate callers more accurately. As the table below shows, location technology was deployed most heavily, by sheer number of sites per mile, in Zone 3 (8 location receivers over 10 miles). Zone 3, as a whole, came closest to reaching the FCC's accuracy requirements.

(2) Placement -- Geometric Dilution of Precision (GDOP). The data indicates that the geometric placement of location technology receivers on various cell sites also played a significant role. GDOP is a measure that describes the degree to which a caller's location is properly surrounded by TDOA equipped cell sites -- at distances where signal strength is sufficient to be measured. The perspectives produced by an optimal number of at least four sites help to produce a more accurate report location. In the trial, lower GDOP measurements generally correlated to more accurate caller location estimates. Utilizing a particular type of software for this trial, a perfect GDOP rating was generally considered to be about 0.5. Zone 3 had the lowest aggregate GDOP rating at 0.8, while Zone 2 had the highest GDOP rating of 1.1.

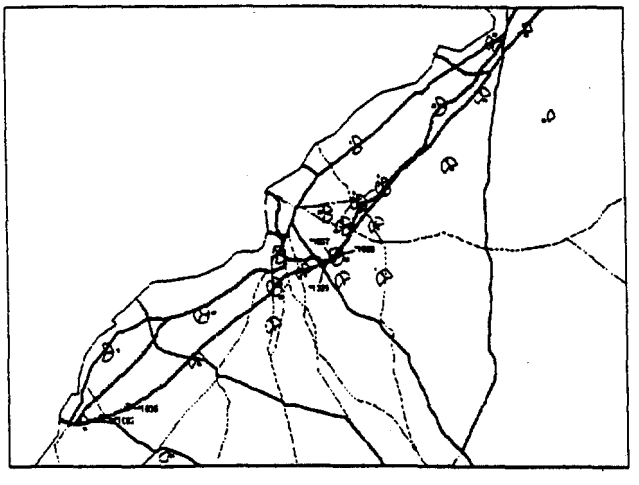
(3) Distance -- Length of Interstate Covered in Each Zone. While Zone 4 had the highest percentage of cell sites equipped with location technology (72%), it did not produce the most

accurate results. Signal strength from transmitters was also a factor in obtaining accurate location reports. While TDOA technology was deployed on 8 of 11 cell sites in Zone 4, the sites needed to cover a longer stretch of highway -- approximately 16.2 miles long -- compared to 10.6 miles for Zone 3. Greater distances often meant weak signals or no signal at all being received at distant sites.

(4) Interference -- Multipath, RF Emissions. In general, the wireless location technology used in the trial overcame significant RF emission interference. Despite high levels of RF interference in Zone 3 due to reflections from buildings and other causes, the system was still very effective. In general, multipath RF was a minor factor in lowering accuracy of location estimates. TruePosition's prior testing in the downtown areas of major cities had worked out most of these issues.

Zone	Density of TDOA Equipped Sites	Placement (Avg. GDOP)	Distance (Miles of Turnpike)	TDOA Sites Per Mile
1	67% (6 Sites/4 Equipped)	1.0	10.8	.37
2	50% (8 Sites/4 Equipped)	1.1	8.1	.49
3	44% (18 Sites/8 Equipped)	0.8	10.6	.75
4	73% (11 Sites/8 Equipped)	0.9	16.2	.49

The test points 1026, 1027, 1028 in Zone 3 for the month of April provide evidence of these factors at work. Each of these test points (see map below) is located between a number of TDOA equipped cell sites which are very dense throughout Zone 3. Each point is surrounded by a number of receivers to transmit a signal to -- translating into a low GDOP of 0.7 for all three locations. And because each is located nearby a cell site (short distance), the signal strength is strong. RF interference did not seem to be a problem either. The result: test point 1026 was located within 387 feet 67% of the time; 1027, 379 feet; and 1028, 336 feet.



Test Figure 15 – Example Points

Zone 1 provides another instructive example of the importance of proper coverage. As shown on the map, Zone 1 coverage had 4 receivers in a diamond configuration. Test point 2 at the southern end of the Turnpike showed a typical error of 800 feet, 67%. It was getting little to no "help" because no cellular antennae to the south, west or north were equipped with receivers. Only the receivers to the NNE and ESE were "helping". By contrast, the results in the middle of Zone 1, at test point 5 (at about the perpendicular intersection of lines connecting the four cell sites covering that Zone, consistently produced accuracy within 309 feet, 67%.

b. Variability -- The issue of calibration

Errors were not consistent over longer times (several days), but measurements were consistent within shorter time frames. Despite the coverage issues noted above, many test sites produced measurements within the FCC Phase II requirement on a regular basis, but then produced significantly larger errors on other days. An example of the day to day variability is shown below:

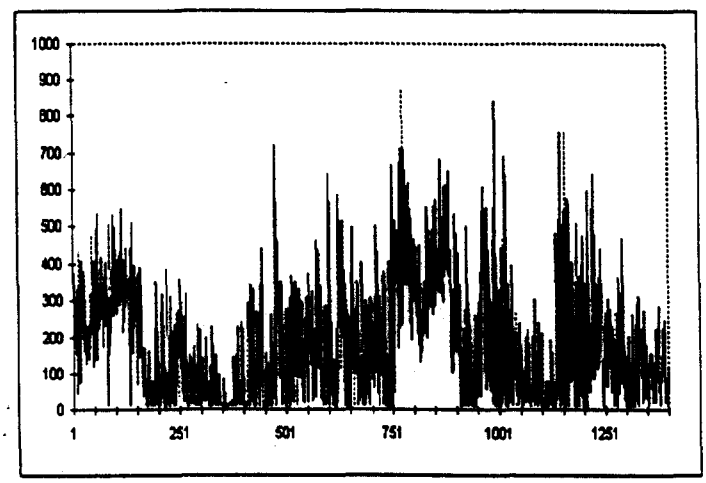


Figure 16 – Example of Day to Day Variability (Error in Feet)

The chart depicts the calculated location of a test phone at a fixed place, where the test phone placed a call approximately every 10 minutes. In this chart, 1,400 consecutive test calls are represented over a multi-day period. The test call sequence number is represented on the horizontal axis, and the accuracy of the calculated location is represented on the vertical axis. As seen in this one example, the accuracy varies, but generally remains below 410 feet through the first 750 test calls over several days. The accuracy then encounters periods of increased variability, then reduced variability.

The day to day variability of the location system was isolated by the TruePosition development team to the technique chosen for time synchronizing the 24 location receivers. This particular technique, known as external calibration, was successfully used in smaller system tests last year, but had never been attempted before in such a large location system deployment, and could not have been attempted without a trial of this scale (50 miles of highway, 350 square miles total).

In a TDOA system, the various receivers within the system must be kept constantly synchronized to within 30 nanoseconds of each other (30 billionths of a second). For various technical reasons, the particular calibration technique chosen proved to be difficult to stabilize over longer periods (many days) of time. The

TruePosition team identified this issue within the first 30 days of the trial, and made all possible software changes to increase the stability as much as possible. Ultimately, however, it was decided that this particular calibration technique was not appropriate for large location systems, and that a different technique should be used. Changing synchronization techniques would have required hardware changes to the TruePosition system, which were not acceptable during the trial period, because it would have meant an interruption in the delivery of the live Phase II wireless enhanced 9-1-1 service of several days.

In the chart of the fixed phone over several days, this synchronization issue can be observed in the drift of the average error. One observable effect of this external calibration issue was that successive location calculations at a particular test point would cluster very well, but that all of the location estimates would be biased to one side or another. The clustering meant that the location system had a very repeatable performance, which is an excellent measure of the success of the technology. The bias was an effect of the calibration technique chosen and therefore could be eliminated by choosing a better synchronization technique. By itself, this bias generally represented between 25-40% of the location measurement error. TruePosition believes it has developed a solution, but as noted, this was not implemented during the test.

VI. Conclusion For The First 100 Days

OETS has drawn the following summary conclusions from the first 100 days of the first live wireless E9-1-1 trial in the United States:

- **Wireless 9-1-1 Call Volume Is Growing**

With the changes made to the 9-1-1 network for this wireless trial, OETS obtained statistics about both wireless and wireline 9-1-1 call volume. On some days, wireless 9-1-1 call volume approached the volume of wireline 9-1-1 calls. This includes calls that came from within the Phase I and Phase II trial areas, as well as calls from other places in the counties that were not included in the trial area.

- **TDOA Location System Solves the Operational Challenges of Wireless 9-1-1 Growth**

The TDOA system solved the operational challenges PSAP telecommunicators are having with the explosion of wireless 9-1-1 calls by providing accurate location data. No live calls produced complaints from public safety telecommunicators concerning incorrect locations. On most occasions during the trial, functionally correct locations of 9-1-1 callers were displayed on PSAP terminals before the dispatcher even heard the caller's voice. From a PSAP operations perspective, the test was a major success.

- **Location Technology Is Available**

While OETS is not endorsing any one technology, the TruePosition system demonstrated its ability to locate wireless 9-1-1 callers within the FCC requirement of 410 feet, 67%. Its receivers need to be on a higher percentage of cell sites, and it must refine its calibration system. There may well be other effective technology which has yet to be tested.

- **Development Issues Were Minor And Can Be Overcome**

No aspect of the trial system was fully complete from a development perspective, but the issues encountered were minor and can be overcome. It is a small step from this trial system, deployed only 6 months after the FCC issued its Report and Order, to fully operational wireless enhanced 9-1-1 systems across the country.

o **9-1-1 Network Impacts Are Manageable**

The changes required to the existing 9-1-1 network and to the PSAPs were easily manageable during the trial, and are forecast to remain so even during a full statewide deployment. Bell Atlantic-New Jersey reported no concerns with the 9-1-1 tandems during the trial.

o **Issue Now Shifts To The Business Side**

As this trial continues to successfully demonstrate wireless enhanced 9-1-1 technology, the deployment issues really shift from technologic feasibility to resolving the business issues between the wireless carrier community and their customers. OETS will encourage all wireless carriers in New Jersey to join in discussions to accelerate implementation. For example, OETS is prepared to universally implement Phase I systems across the State within the next six months.

o **FCC Clarifications Would Resolve Any Vagueness During Carrier Discussions**

As the first to implement live wireless enhanced 9-1-1, OETS encountered issues in the Report and Order that could be helped with some clarification from the FCC. These are detailed below.

o **Vendors Are Asked To Continue The Trial**

Due to the success of the trial, and the benefits received by both the citizens of New Jersey and the 9-1-1 PSAPs of Salem, Gloucester, and Camden counties, OETS has urged the vendors involved to continue the trial. Several of the wireless trial participants would like an opportunity to make further improvements now that the initial trial period is completed. All of the participants are interested in continuing the trial.

VII. Clarifications to the FCC Report and Order

Based upon its experience with planning, implementing, and testing during this first wireless enhanced 9-1-1 trial, OETS would like to suggest the following clarifications to the FCC Report and Order. This clarification would likely aid other 9-1-1 agencies and carriers nationwide in implementing wireless enhanced 9-1-1 systems.

A. Measurement of the location system accuracy should be the 67% point

The FCC Report and Order in Docket 94-102 discusses the measurement of location accuracy in various terms. The dominant discussion in the Order and certainly in public has been the 67% accuracy point. The 67% point of a data set of location measurements is calculated by ordering the location measurements from smallest value to largest value, and then identifying the value, or point, at which 67% of the measurements are smaller than the identified point, and 33% of the measurements are larger than the identified point.

The Root Mean Square (RMS) of the data set is also mentioned in the report, however, which has created some confusion. The RMS measure of accuracy is calculated using a separate process whereby the value of each of the location errors is squared, then all of the squared values are summed together, then the sum is divided by the number of location measurements in the set, and lastly, the square-root of the result is calculated. During the location trial, many data sets were analyzed, and both the 67% point and the RMS value of the data set were determined. The values are rarely the same, and the RMS value can be greater than or less than the value the 67%

point. Therefore, there is no one true measure of the statistics of a data set. Rather, one method should be chosen and implemented universally for the sake of consistency.

The recommended method for measuring the statistics of a location measurement data set is the 67% point measurement. It is a simpler method and is consistent with the recommendations of the NENA Technical Subcommittee last year during the proceedings of Docket 94-102 that a measure be chosen that yields a known, consistent percentage of calls within the chosen accuracy.

B. Wireless 9-1-1 calls should be routed by caller's location in Phase II systems

The wireless E9-1-1 trial in New Jersey routed calls by caller's location when the caller was in the Phase II coverage area of the system. Otherwise, the call was routed by cell site location. The test area was covered by four regional county PSAPs with large and clearly identified service areas. However, even with these large service areas, calls routed by cell site location (i.e. Phase I methodology) were inappropriately routed approximately 30% of the time. In other areas of New Jersey where cell sites cover several jurisdictions, inappropriate routing approaches 100%. The Report and Order does not explicitly address this change in routing methodology from Phase I to Phase II, but OETS recommends this clarification because of the benefits obtained from not only calculating the caller's location, but also routing the call based upon that location.

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